Milling and Concentration
1870’s – 1940’s

The second of the “Mining for Modelers” clinic series

“Mining for Modelers” Clinics

- Mining 101: Underground Mining
  - Gold, copper, iron, and silver-lead-zinc, 1870’s – 1940’s
- Mining 102: Milling and Concentration
  - Examples from Ag-Pb-Zn, Fe, Au, 1870’s – 1940’s
- Mining 103: Smelting of Ores
  - Examples from Ag-Pb-Zn, Fe, Au, 1870’s – 1940’s
- Mining 104: Coal and Coke
  - Underground mines & examples of surface facilities
- Mining 105: Steel Mills
  - Steel and product making process, 1910’s – 1970’s

Steps in the overall mining process

- Exploration for a mineral deposit
  - Is there anything of interest out there
- Evaluation of the deposit economics
  - If there is no value, there is no mine
- Design, development, and cost analysis of the deposit
- Production of “ore”
- **Beneficiation** (milling and concentration)
  - Liberation, separation, and concentration of the economic values from the uneconomic values
- **Refining**
  - Purification of the economic value into the substance needed by society

What is typical?

- For model RR's, "typical" is:
  - Small underground gold mine/mill operation
    - Early gold & silver operations typically processed gold and silver into "dore" bars
    - Dore shipped to a smelter/refinery for purification
    - Associated mills were small, 50 – 200 tons per day
    - Mine + mill might employ 10 – 50 people total
    - Site *might* be served by rail access
      - Rail access typical in late 1800's, not so much by 1940's

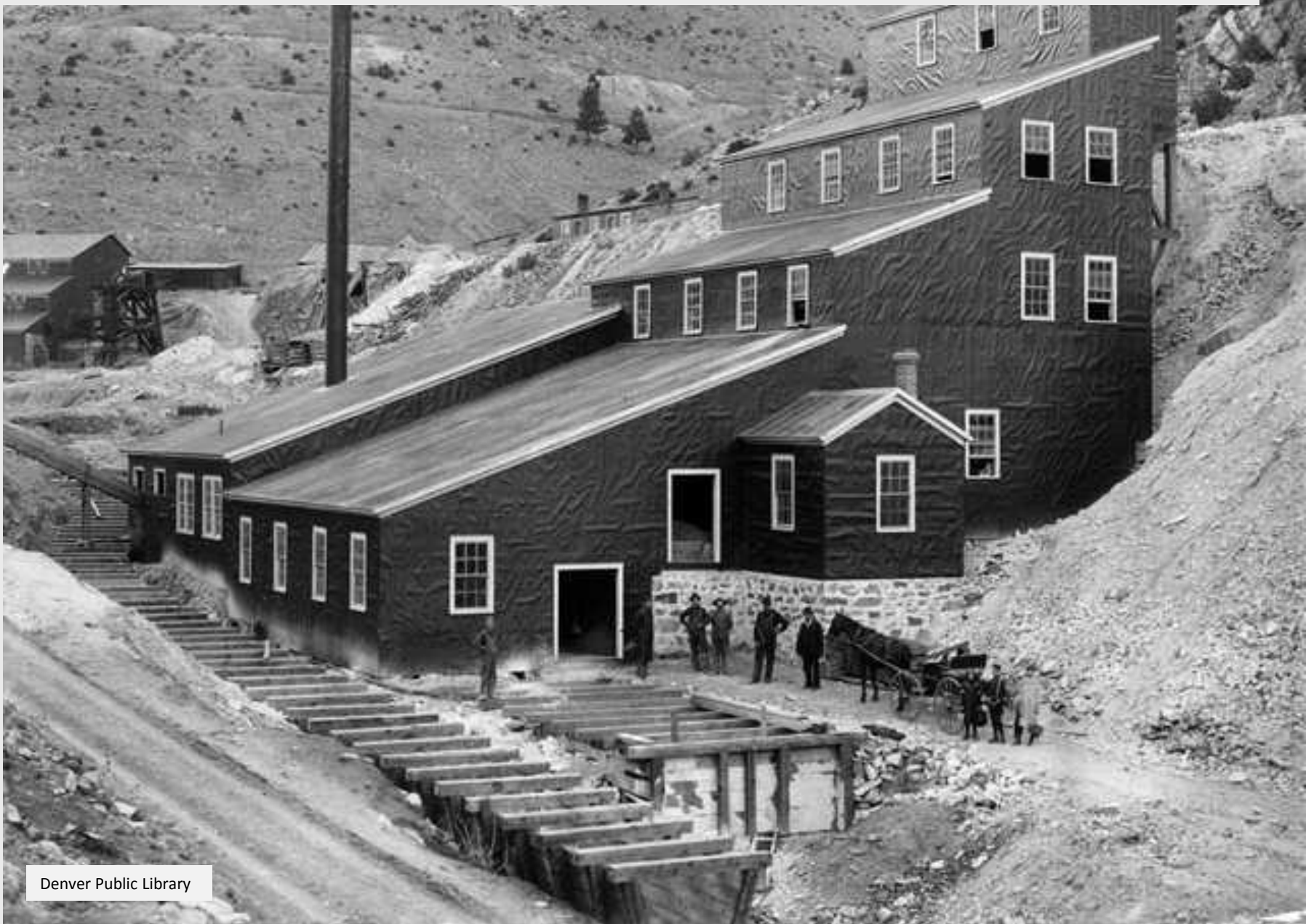
What is model RR “typical”?

- Medium size mill operation
  - 100 – 500 tons per day
    - 10 total, 50 ton car loads per day inbound ore
  - Lower value ‘bulk’ ores: copper, silver, lead, zinc
  - Ores brought in by RR or aerial tram from distant mines
  - Mill might employ 25 – 100 people
  - Ore reduced by 20 to 15,000 : 1
    - 100 t, 5% lead = 5 tons of concentrate for smelter (20:1)
    - 100 t, 2% copper = 2 tons concentrate for smelter (50:1)
    - 100 tons of 100 oz/ton silver (0.35%) = 71 pounds of silver for refinery (300:1)
    - 100 tons of 2 oz/ton gold (0.007%) = 13.8 pounds of gold for refinery (14,492:1)

What is “prototypical” mill

- Early days: 100 – 1,000 tons per day
  - 1860’s – 1890’s
- Middle era: 1,000 – 5,000 tons per day
  - 1890’s – 1930’s
- Modern era: 10,000 – 100,000 tons per day
  - 1930’s to present
  - Imagine:
    - 1 ton = 12 cubic feet, so 100,000 tons = one (1) acre covered 27 ½ feet deep with rock!

Oliver Mill, Blackhawk, 1880's, +/- 50 tpd, Au



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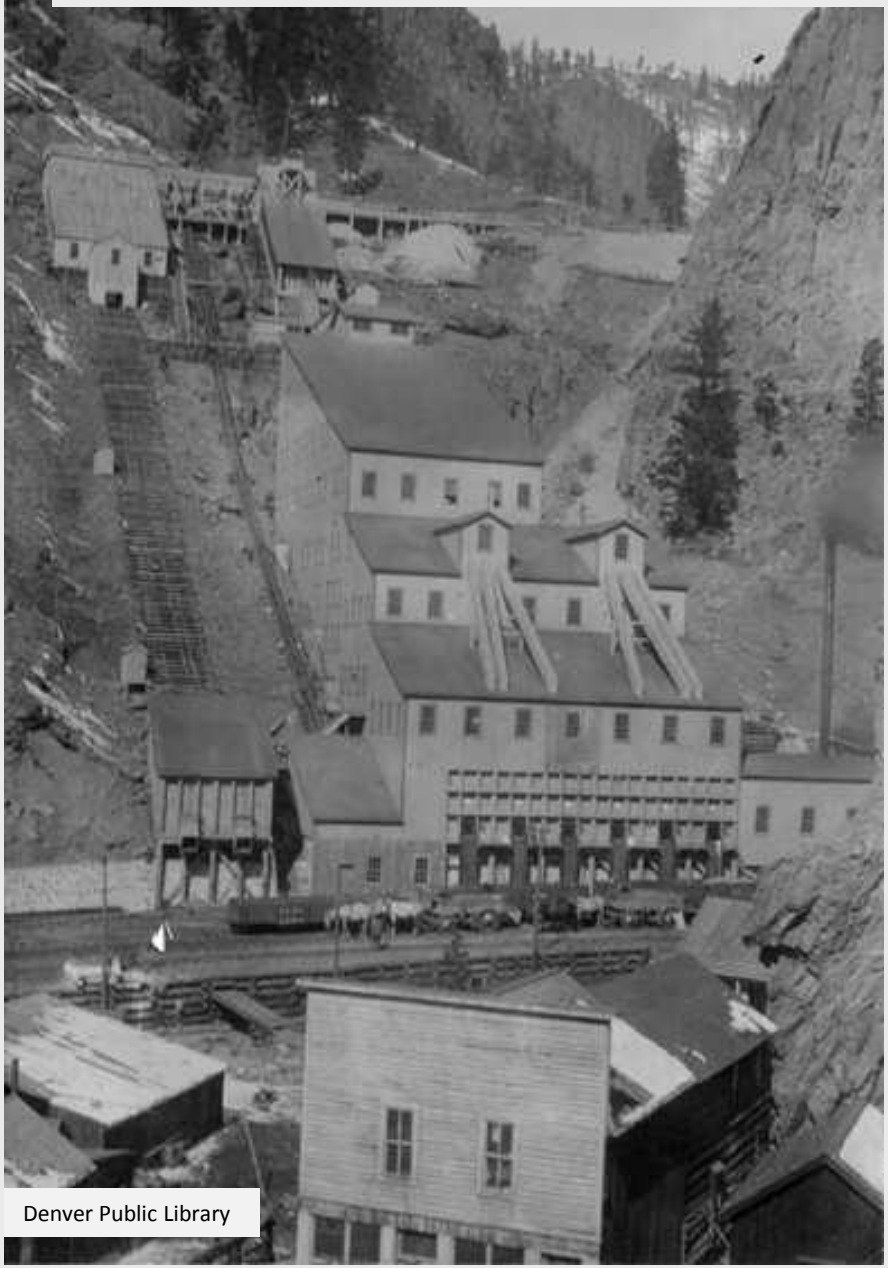
Humphreys Mill, Creede, 1901, +/- 200 tpd, Pb-Zn-Ag



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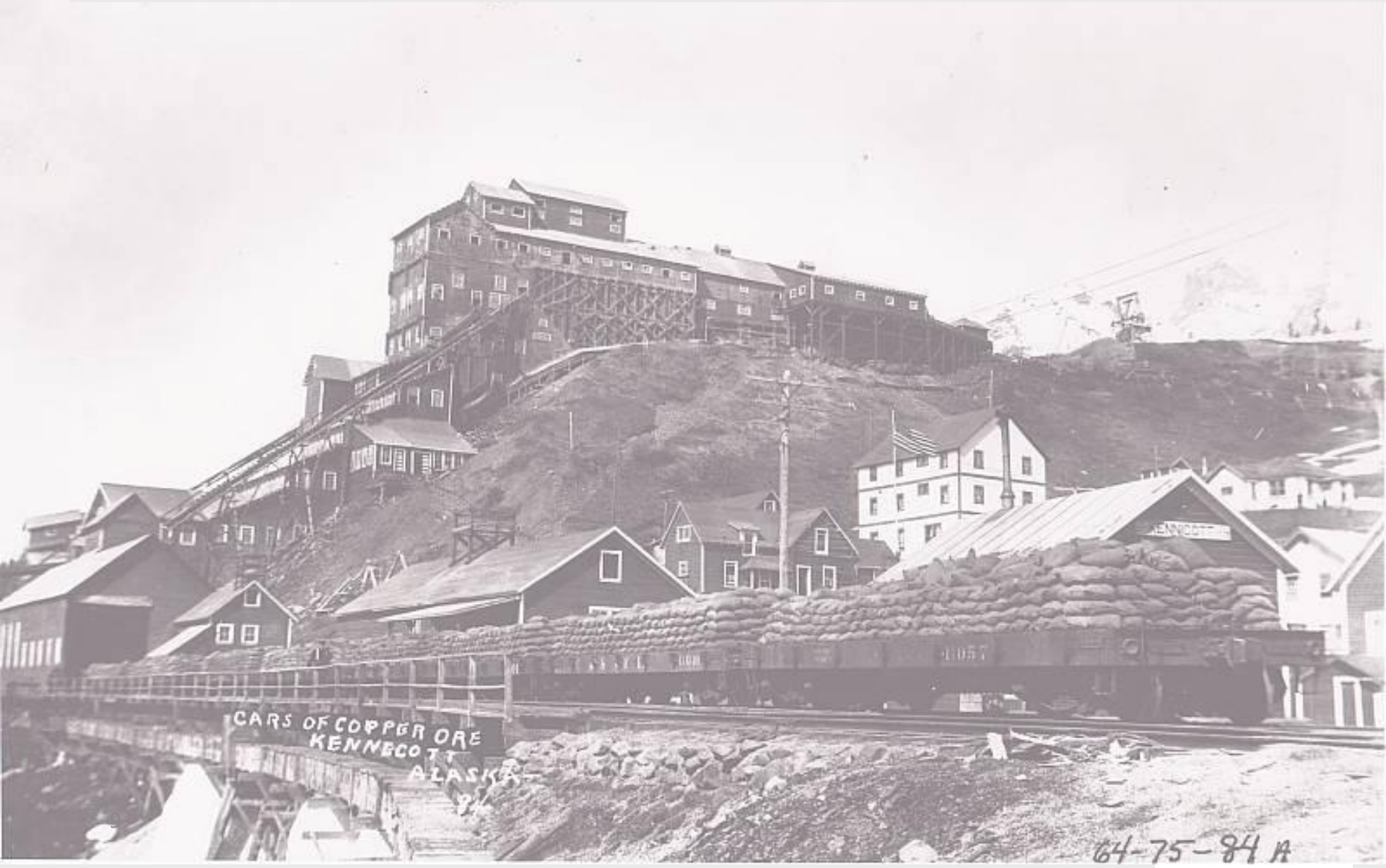
Kennecott Mill, Alaska, 1910's. +/- 250 tpd Copper

Copper concentrate bagged and shipped by rail to local port



Utah Consolidated Magna Mill, 1918, ~10,000 tpd Cu

Kennecott Copper, Magna Mill 1940's, ~50,000 tpd Cu

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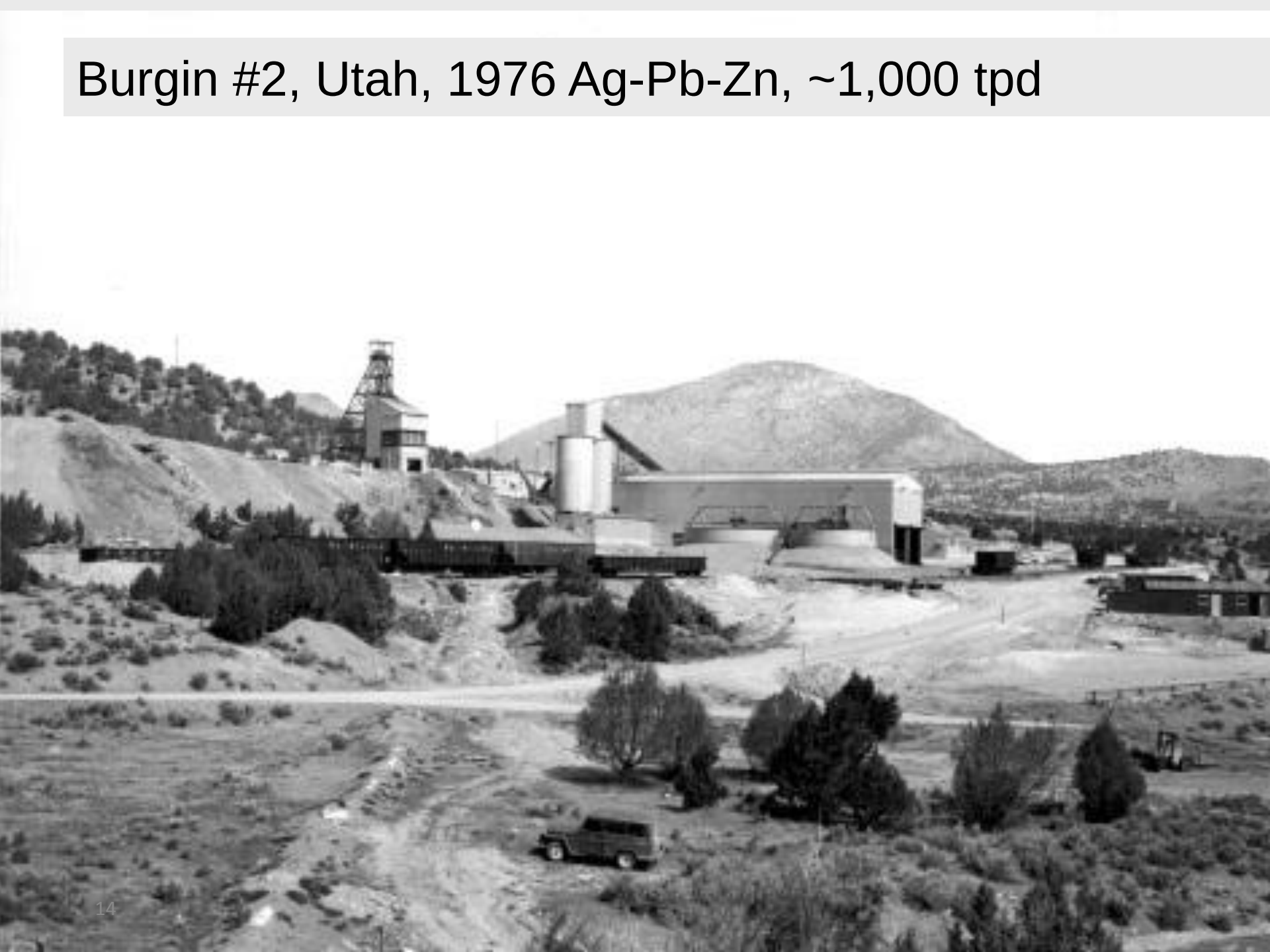
Small gold mine & mill complex

- Not often served by rail in 1940's

Climax Molybdenum, Colo., 1943, ~10,000 UG tpd

Colorado School of Mines NMHFM-556.gif

Burgin #2, Utah, 1976 Ag-Pb-Zn, ~1,000 tpd



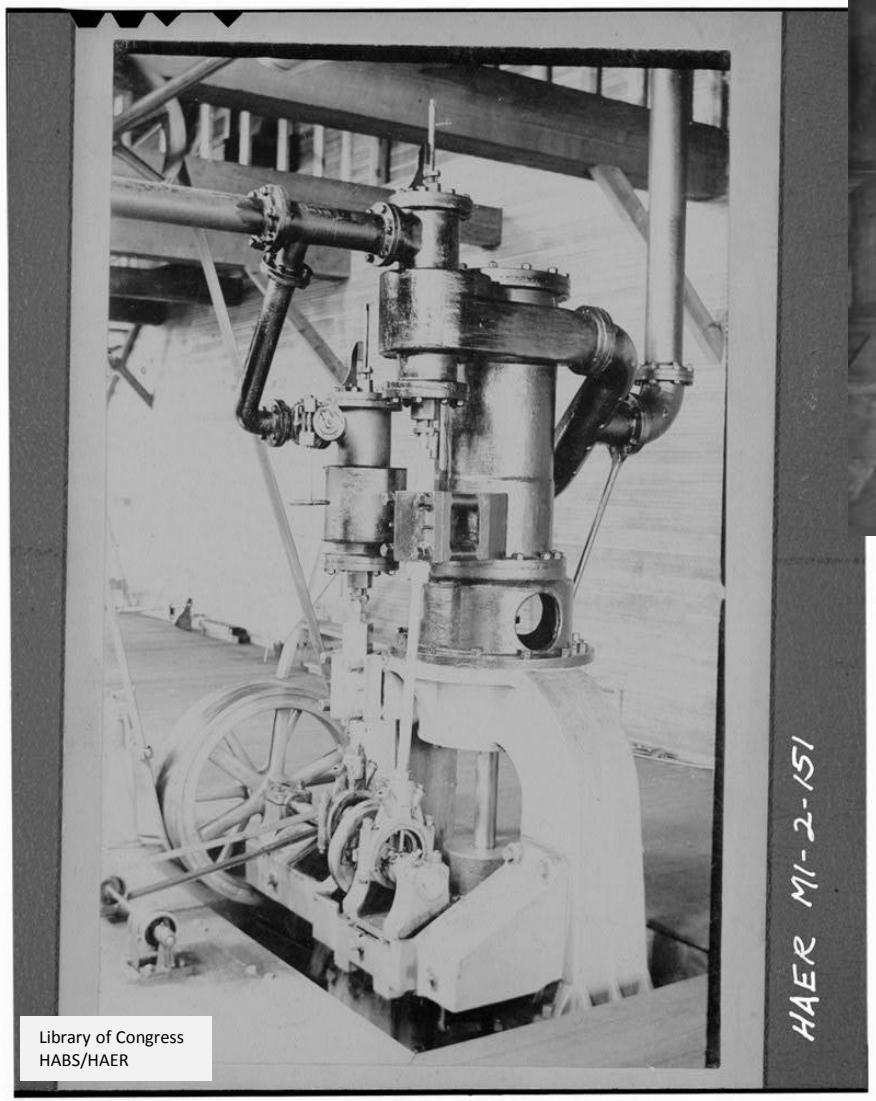
Mills and Milling Processes

Logistics

- Materials into the mill (concentrator)
  - ***ORE!!***
  - And:
    - Milling machinery
      - Tanks, pumps, process equipment, air compressors, grinding mills, crushers, large and small electric motors
        - » Flat cars, box cars
    - Fuel (coal, wood, oil) for boilers and blacksmith shops
      - Hoppers, gondolas, flatcars (wood). tank cars
    - Chemicals/reagents for recovery processes
      - Barrels, drums, bags, etc.
        - » Box cars, tank cars (modern) etc.
    - General supplies:
      - Pipe, hoses, tools, parts, sheet, plate & structure steel, lubricants
        - » Box cars, flat cars, gondolas
    - Concentrate packaging materials:
      - Boxes, drums, bags, crates

Machinery

- Steam powered pumps, stationary steam engines, electric motors



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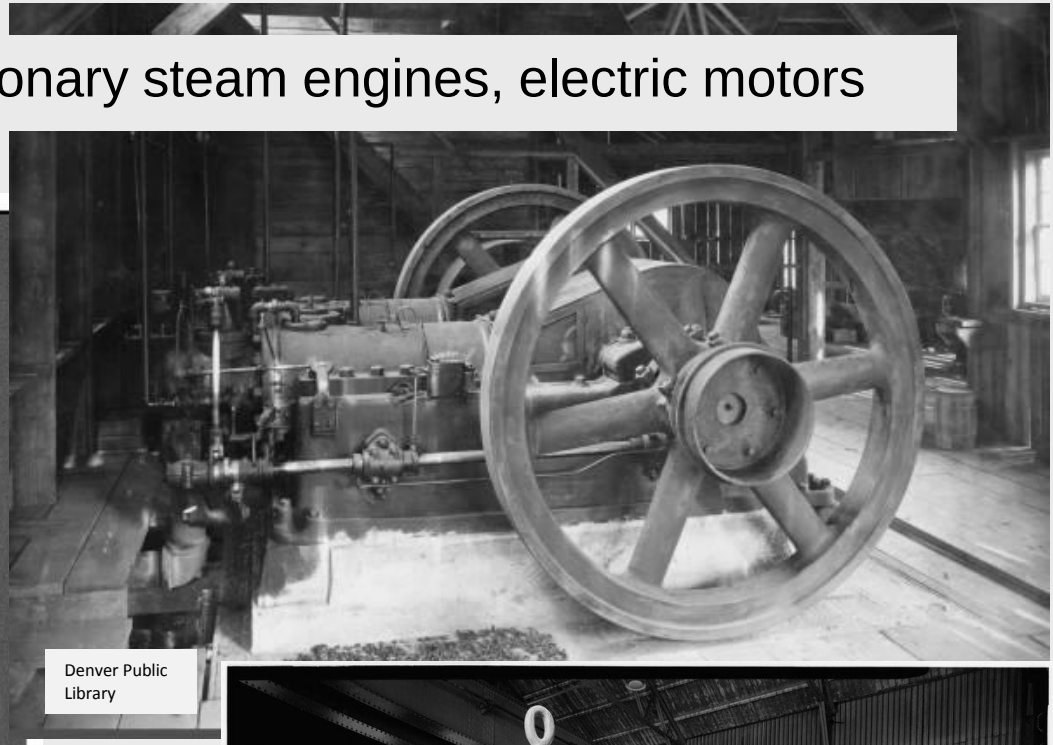

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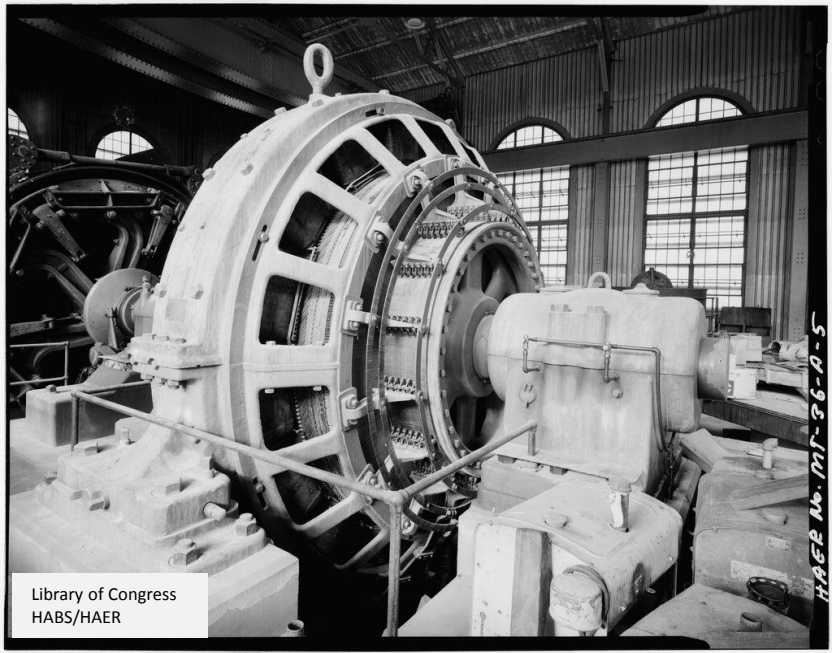

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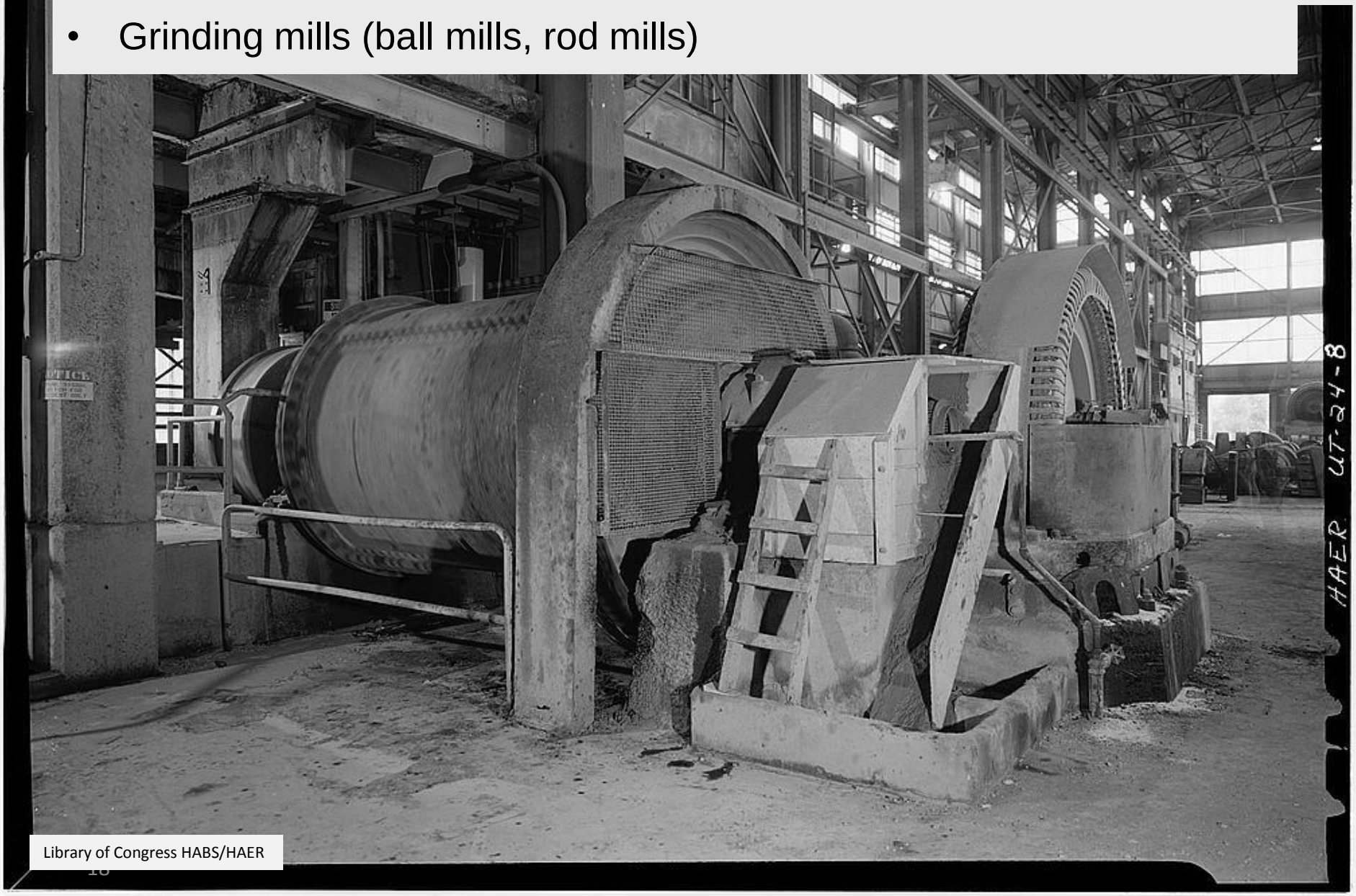
Machinery

- Grinding mills (ball mills, rod mills)



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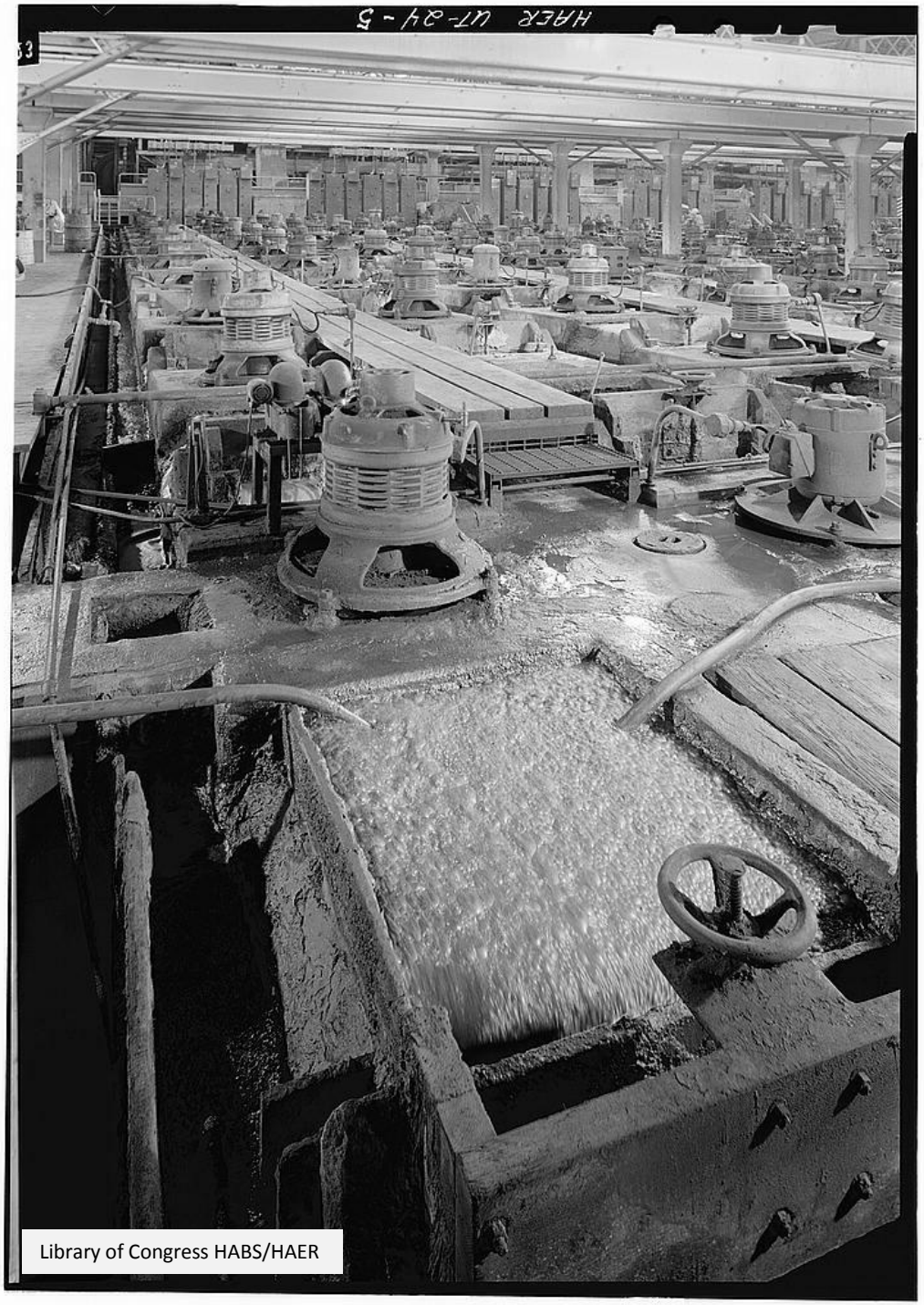
Machinery

- Flotation cells



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Logistics

- Material out from the mill
  - Concentrate
    - Hopper cars, gondolas, box cars, occasionally flat cars
    - Shipped to smeltes
- Whatever came to a mill tends to stay on site.
  - Other than concentrate, very little ever leaves. Mills tend to have huge “bone yards”
    - Occasionally they let scrappers in

A Look at Various Milling Processes

Milling

- A quick look at the process:
  - Transport – receive ore
  - Grind it very fine, to consistancy of powder
  - Separate and concentrate the “values” from the “gangue”
    - Flotation process gives powder-like, granular concentrate
      - Copper,lead, zinc, iron pellets, platinum, etc.
      - Other processes for limestone, fluorspar, salt, titanium, etc.
    - Cyanidation process gives ‘dore’ bars
      - Gold, silver
  - Packaging the ‘values’ in a form suitable for transport and further processing (smelting, refining)

Transport of Ore to Mill

- Aerial Tramways
  - Ore hauled or hoisted out of mine, stored in ore bin
  - Ore bin discharges into tram buckets which are moved by cable to mill
    - Tram buckets usually hold 500 pounds of rock
    - Cycle into tram houses about every 90 seconds
    - Ore went out, supplies cam in
      - Lumber, coal, supplies, etc.
    - Can model both ends of the tramway

Mine rail haulage dumps into ore bit outside portal

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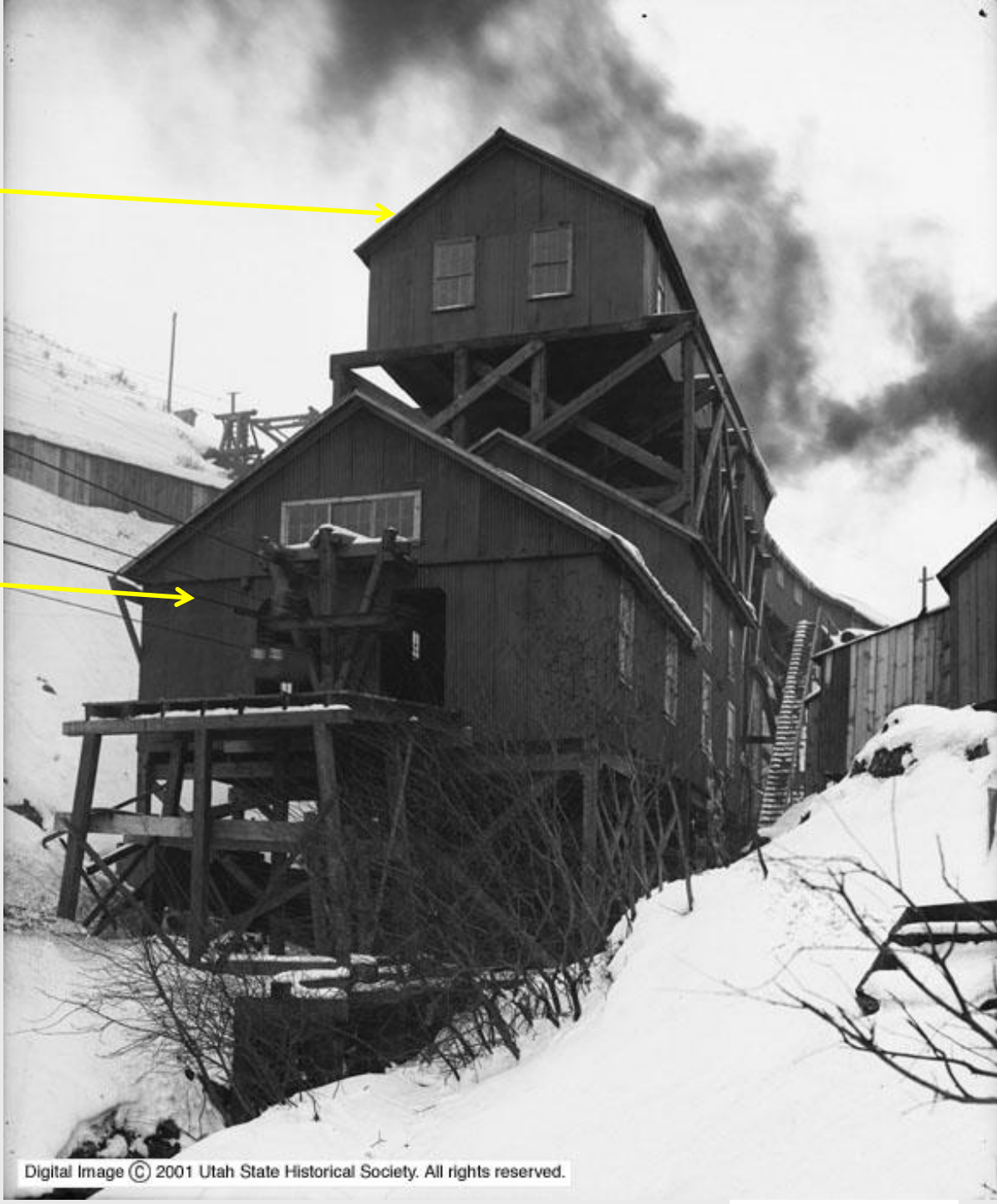
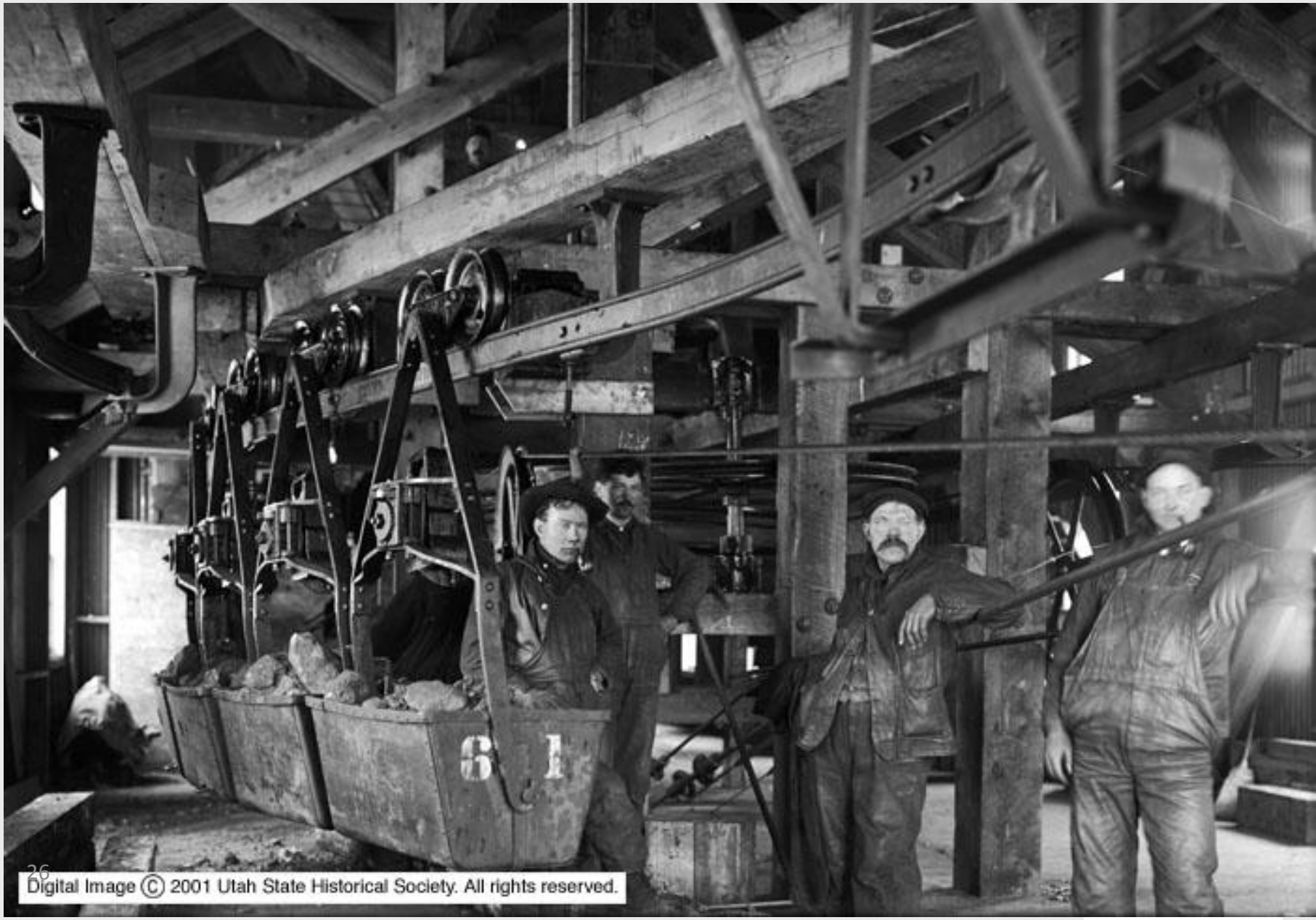
- Weatherproof rail haulage to aerial tram
  - Leads from mine portal (or possibly mine shaft head) to “surge bin” feeding tram buckets
- Mine discharge end of aerial tram
  - Buckets travel down to mill
  - Supplies come uphill to mine

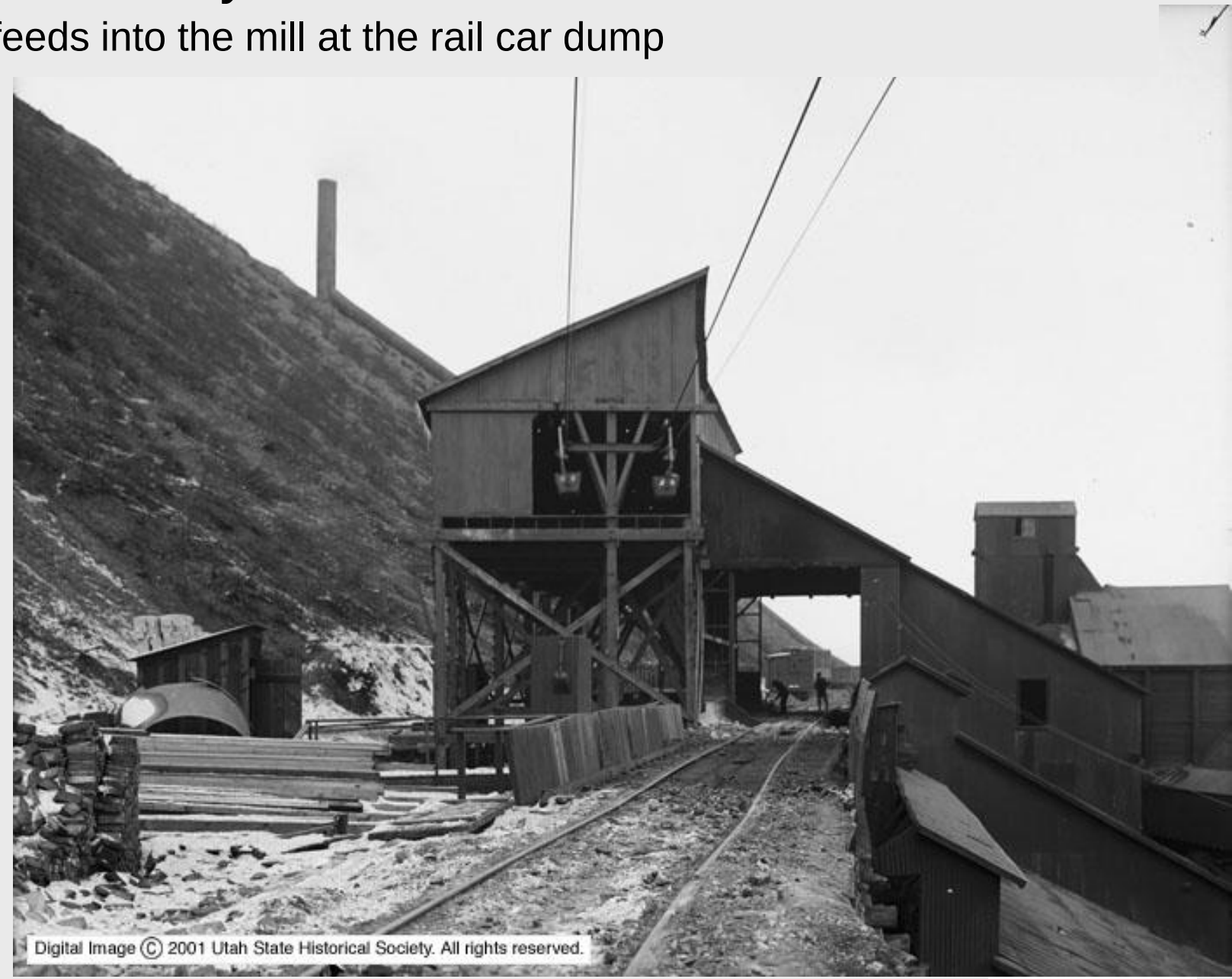


Loaded rock buckets ready to launch



Aerial Tramway terminus

- Ore feeds into the mill at the rail car dump

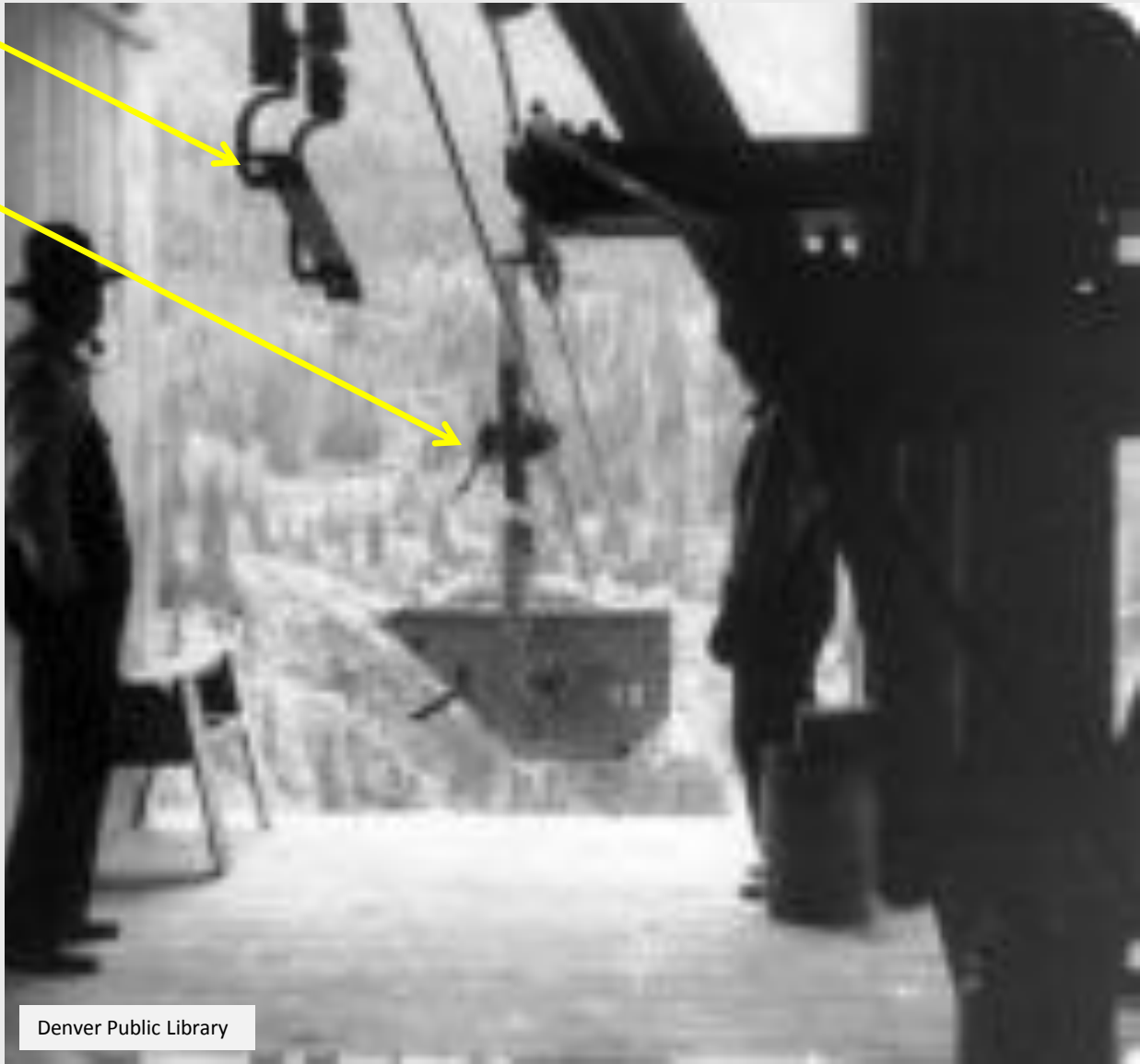


Tram terminus interior

- Loaded bucket #74 on right, empty #73 on left
  - Bucket dump in corner behind #74

Incoming load

- Automatic latch release frees bucket from cable so it can be manually handled as needed
- Bucket rides on solid rail (previous slide) until reatttached to moving cable.
- Stationary cable is very thick to support all buckets
- Traveling cable is less thick



Dumping tram bucket into terminus ore bim

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Tram terminus – Ore bins for rail haulage to mill

- Loaded bucket on its way in

Tram terminus for rail haulage to mill. Park City, Ut.

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Aerial Tramway

- If you had to take a corner, you had to have a “curve station”
  - Amethyst vein, Creede, Colo. Building still existed in 1997

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Short towers took cableway over the top of ridges

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Tall towers kept the cableway out of the bottom of valleys and gulches

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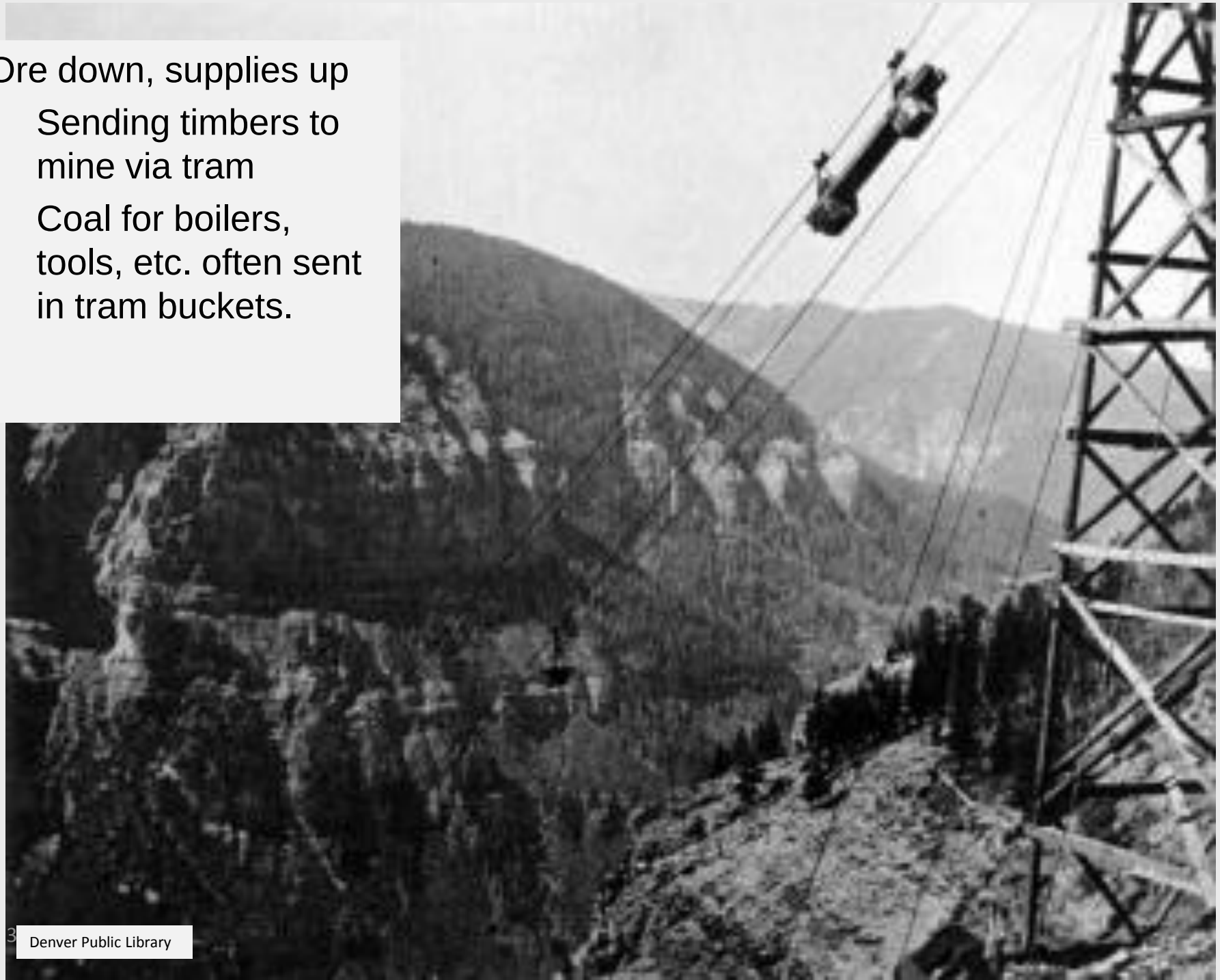
Ore down, supplies up

- Sending timbers to mine via tram
- Coal for boilers, tools, etc. often sent in tram buckets.



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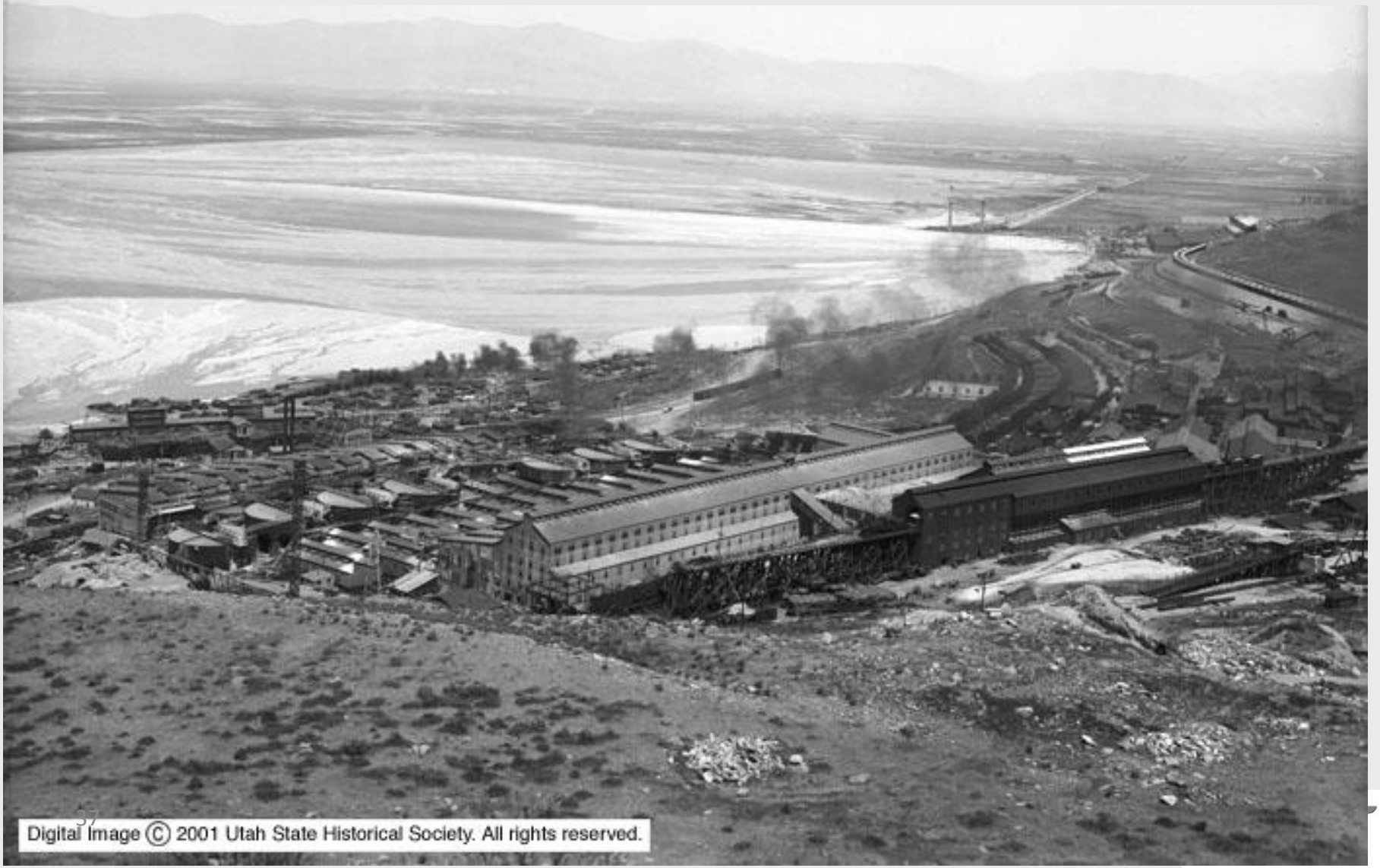
Other arrangements for receiving ore at the mill.

Direct rail haulage to mill ore bin. Utah Copper, 1918



Unloading via Rotary Dumper

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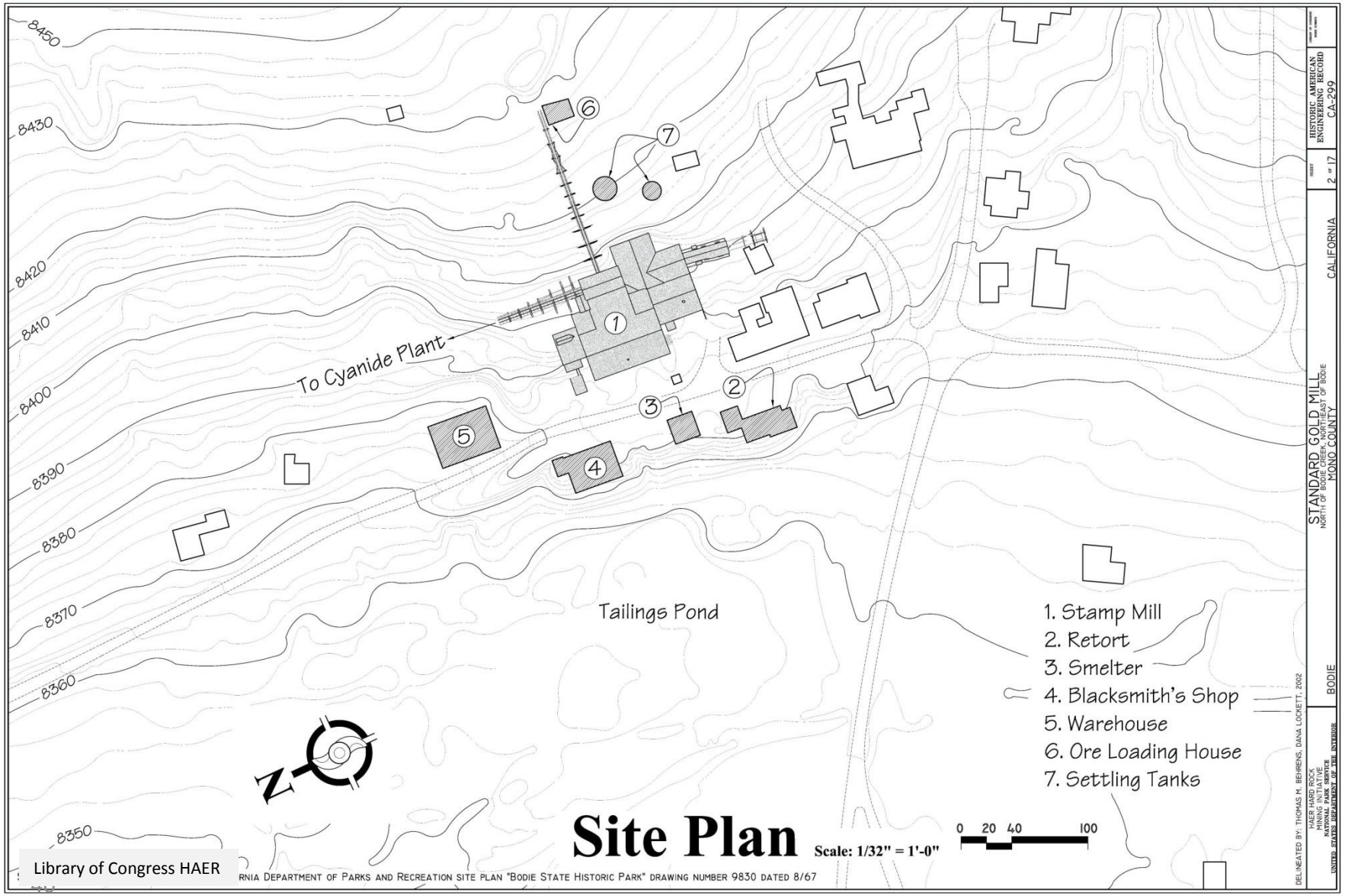
Bodie, California. Now a California State Park

Bodie Mill Layout. (Not actually served by rail.)



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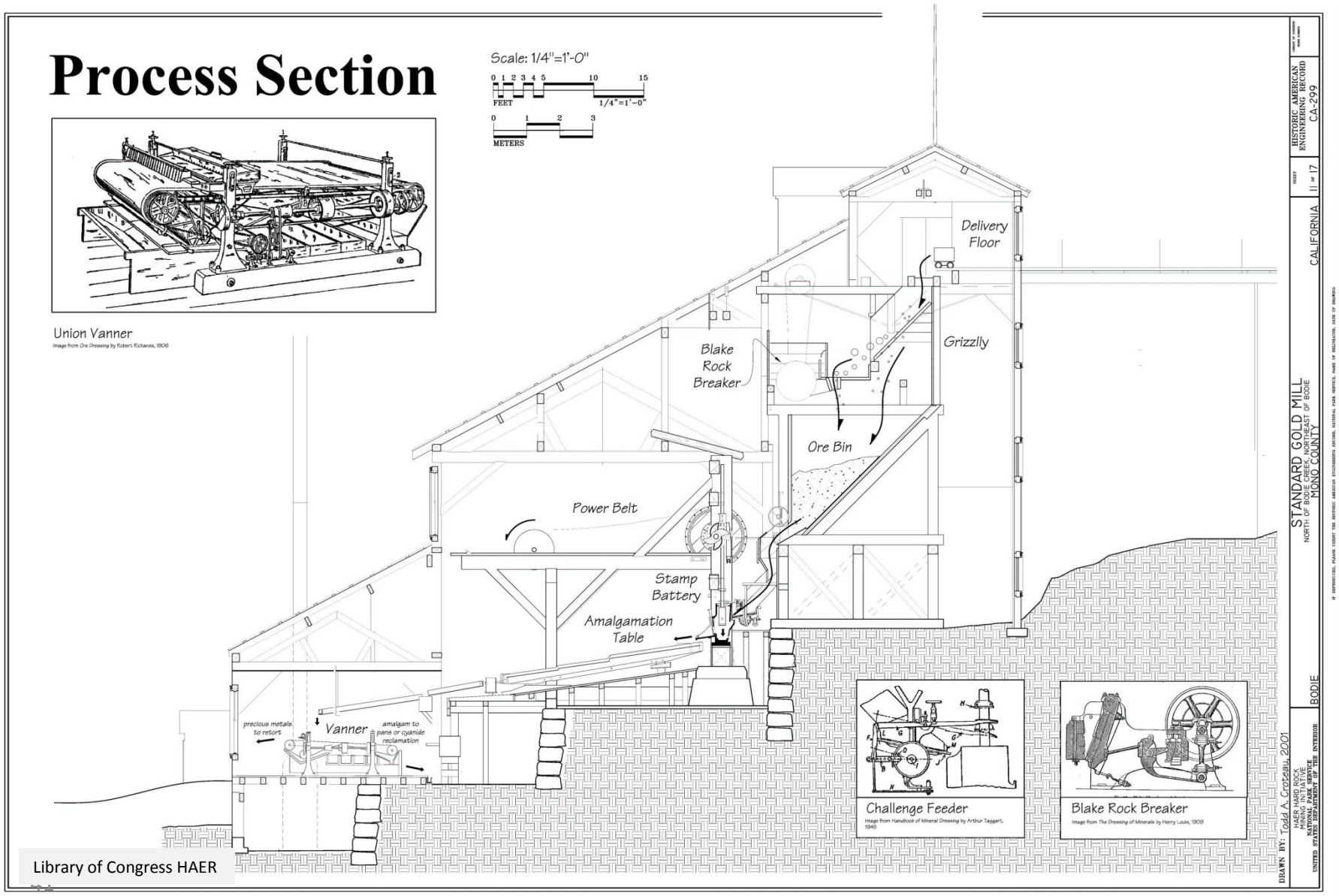
Mill Cross Section



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Mill Ore Delivery by ore car pulled from left

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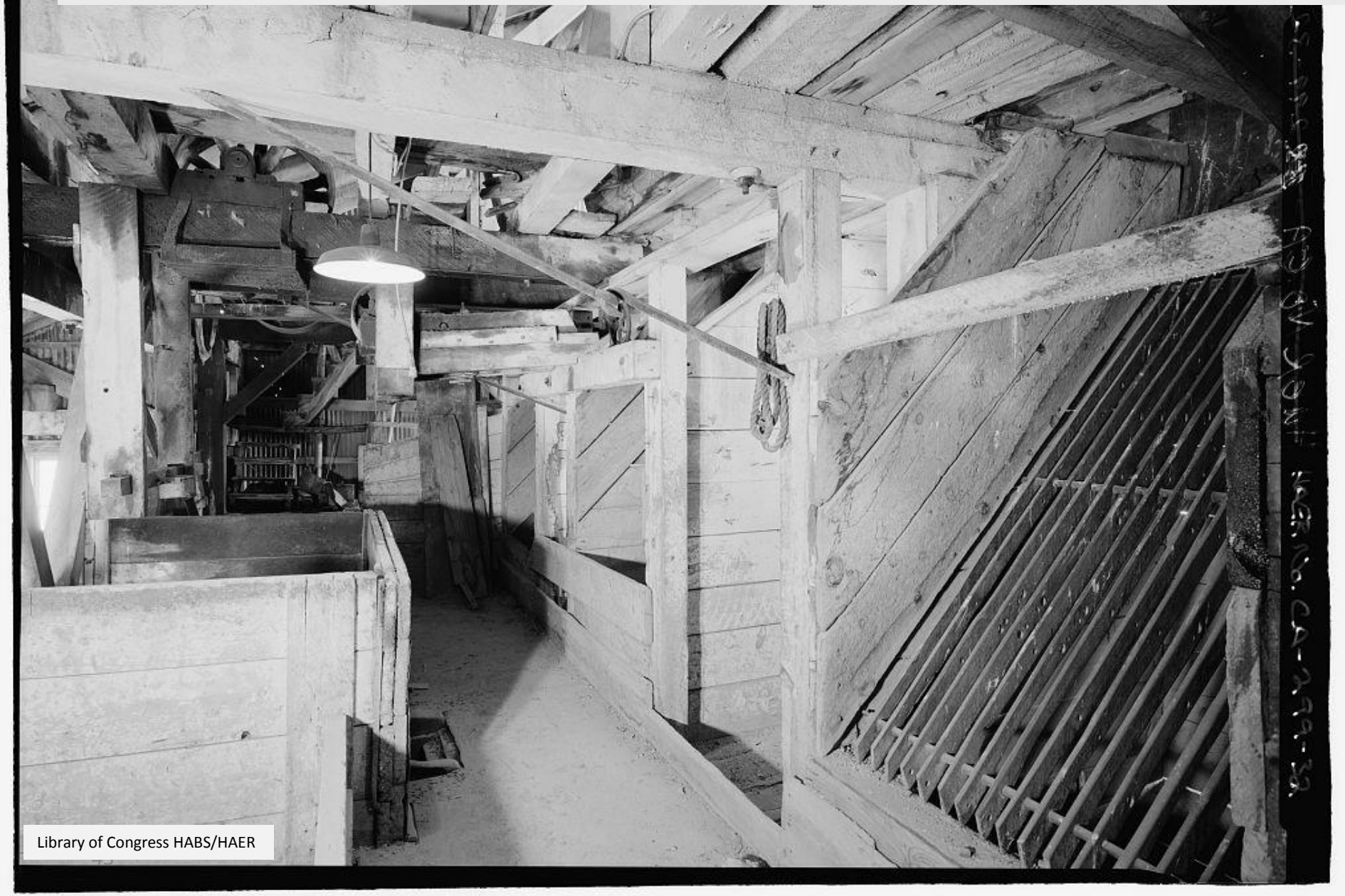
Grizzly level feeds into fine ore bin below



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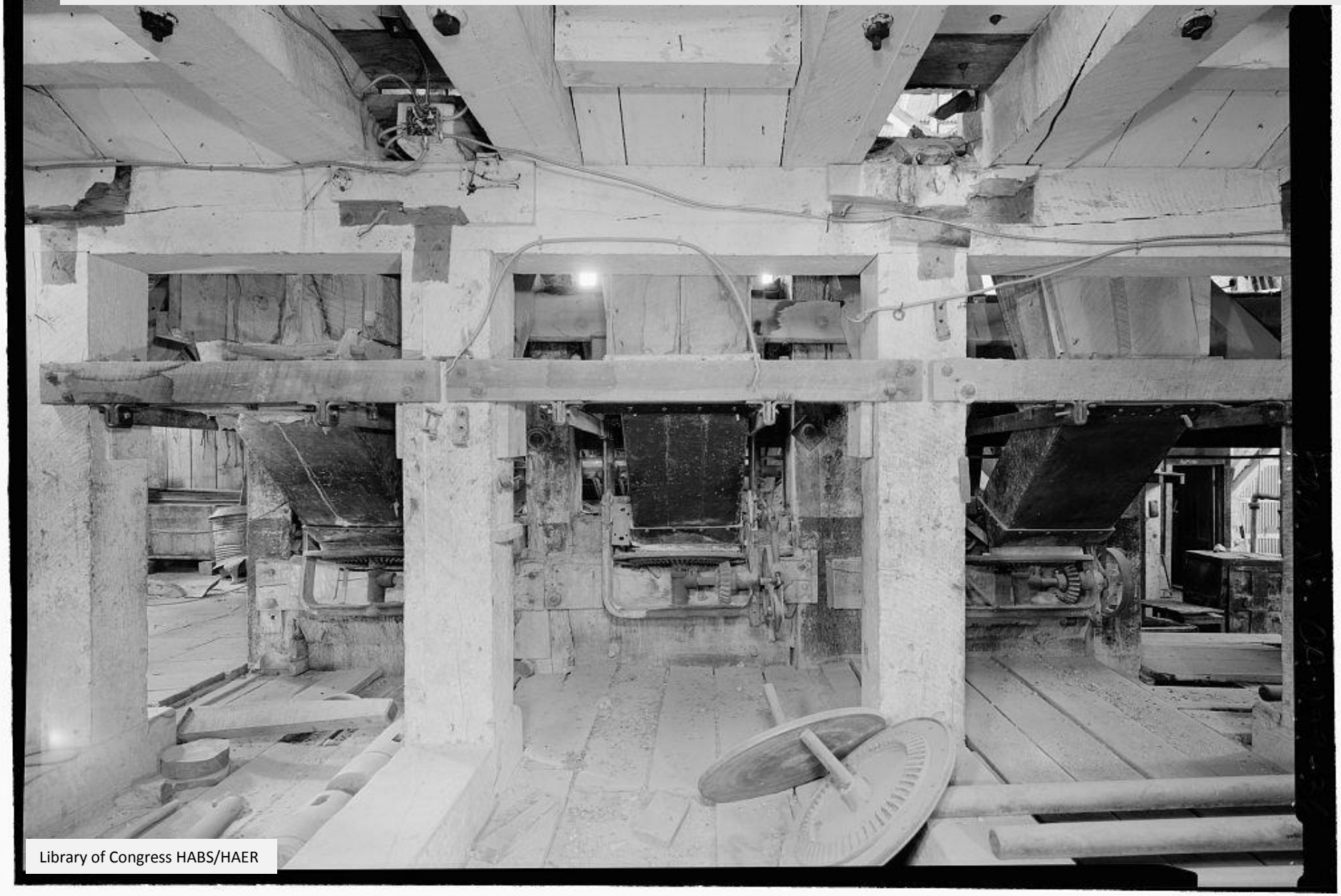
Fine ore feeds to stamp battery



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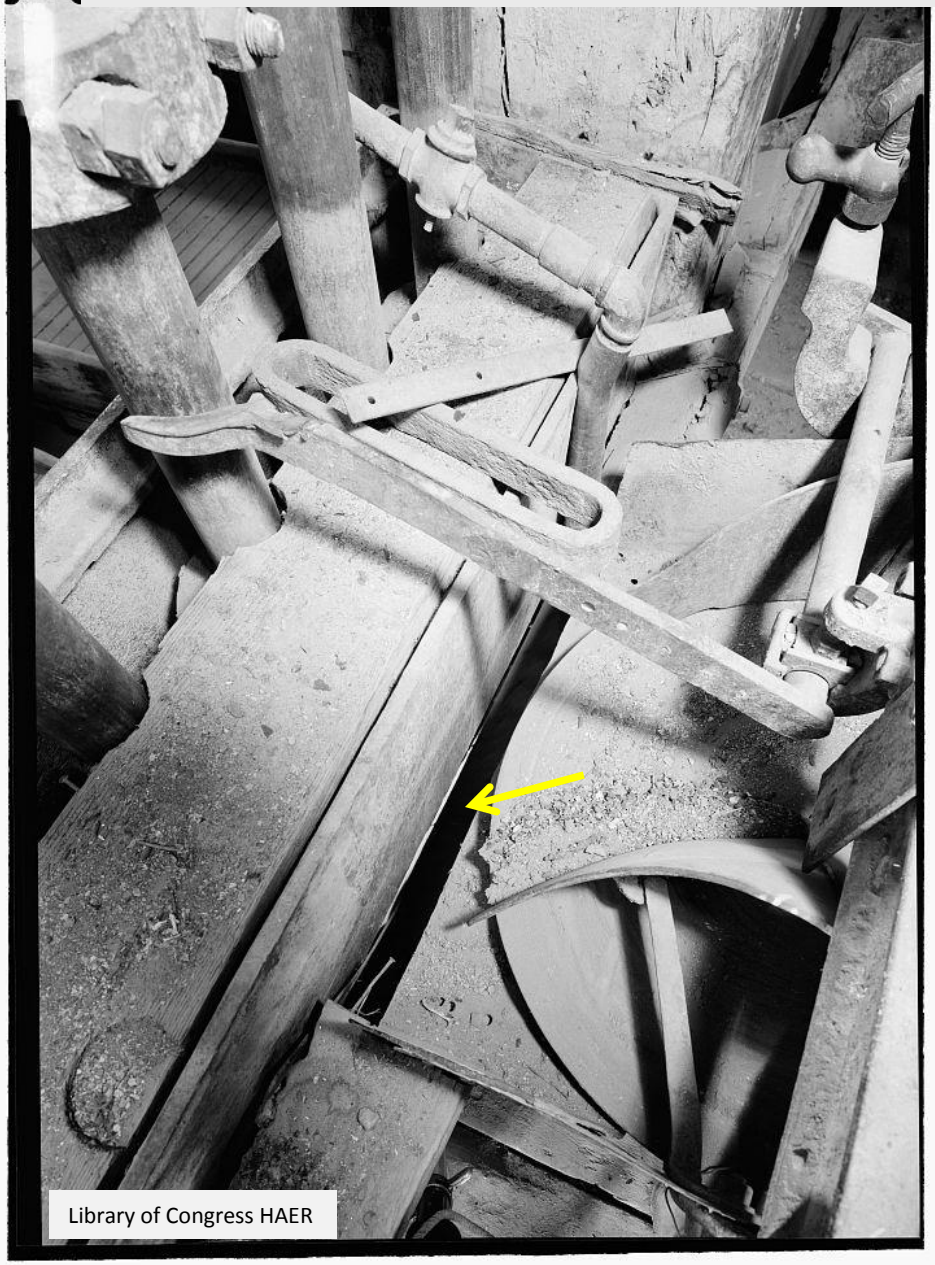
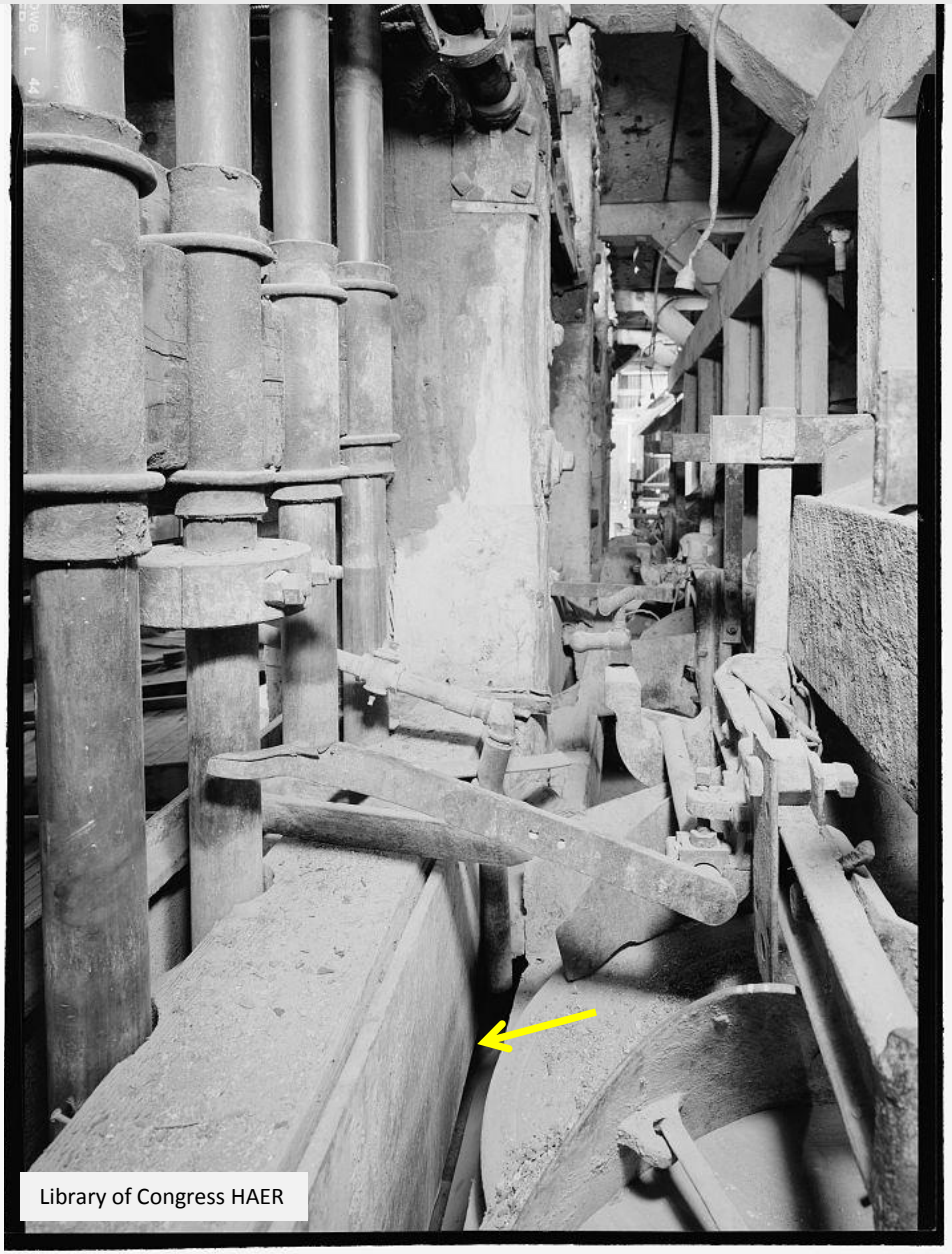
Ore Feeders. Ore falls from feeder pan to stamp battery





Drive Level of stamp battery

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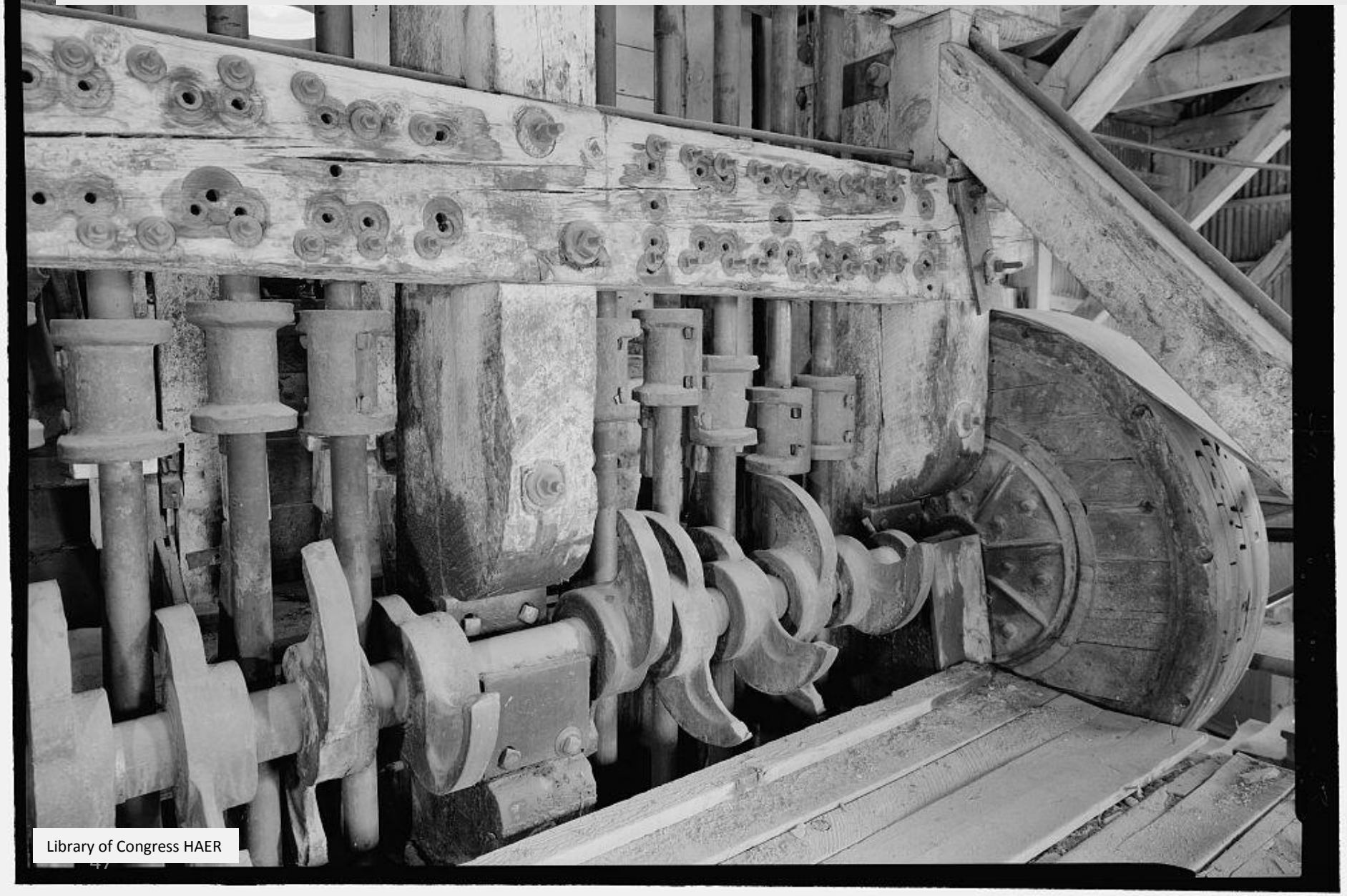
Stamp Cams



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Stamps and amalgamation tables

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Amalgamation tables

use mercury coated copper sheets and ‘riffles’
Amalgam is gathered and later distilled off, leaving gold behind

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Classifiers separate coarse sand from fine

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Belt filter dries concentrate from vanning tables

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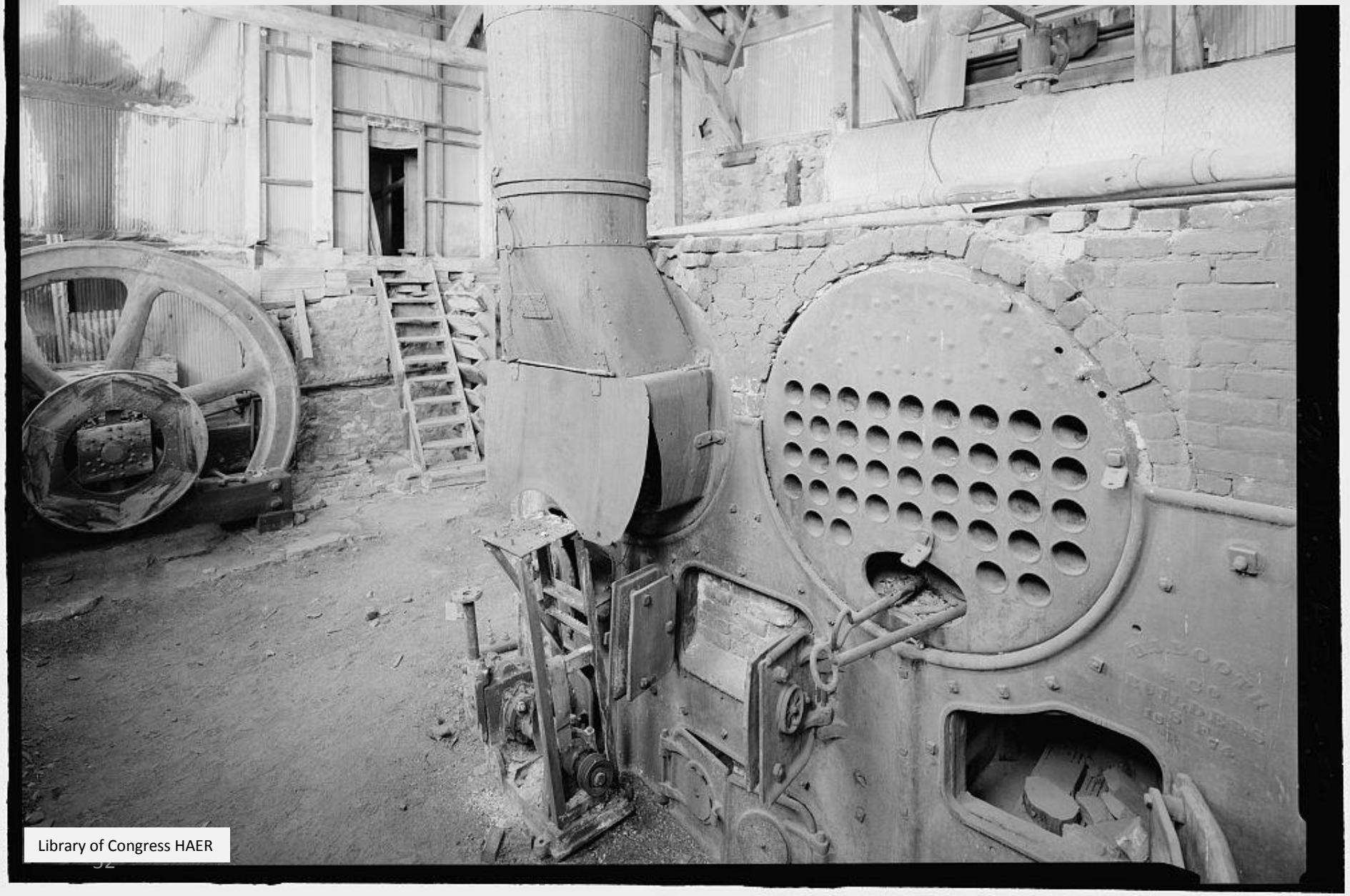
Mill Boiler ram mill before electrification



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Mill machine shop

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